

## The development of science process skills in visually impaired students: analysis of the activities

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### ABSTRACT

Students with visual impairments face tremendous challenges in daily life while learning life skills as they do not have the benefit of visual cues. The skills that visually impaired students are expected to learn include not only everyday life skills, but also scientific process skills too. In this study, case study was used to develop an instructional design to teaching science concepts to visually impaired students. The aim of this study is to analyze the efficacy of science activities of this developed instructional design. The study consists of three basic stages. In the first stage, visually impaired students' learning needs are identified. In the second stage teaching materials and activities are designed and developed. In the last stage, these activities were analyzed in terms of scientific process skills through observation forms. As a result, most of the developed activities are suited for development of the scientific process skills.

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## 1. INTRODUCTION

There is no doubt that the science has an influence striking on changes in the modern society and there is no challenge or threat affecting our society that does not have an appropriate solution through scientific research. Science helps us to describe, explain, define, investigate, and ultimately try to brighten and clarify the real world phenomena and how it works. Besides that, science integrated with technology is increasingly important to economic and social well-being and improving quality of life. National Science Education Standards [NSES] has a vision of scientifically literate individuals as those who needs to know, understand, or be able to predict natural phenomena [1].

Scientific literacy skill is conceptualized various ways but generally known as the knowledge, understanding and shaping of our daily lives by decision making, interacting with environment, asking questions that derived from curiosity about everyday experiences and finding or determining answers to questions. Such essential skills for students to develop their abilities in science are also known as numeracy skills. Students should able to learn how to build or develop self-confidence and improve their self-esteem and to learn the ability how to apply these skills to different learning areas such as at school and in their lives beyond the classroom. On the other hand, scientific literacy does not only mean to be a part of the scientific process, it is also expressed by National Research Council, [NRC] as “scientific literacy entails being able to read with understanding articles about science in the popular press and to engage in social conversation about the validity of the conclusions” [2]. That is, briefly scientifically literate students should be able to interpret the quality of scientific knowledge on the basis of its source to define and clarify the issue faced in daily life, use the scientific methods and find reasonable answer of issues underlying national and local decisions.

The principle to ensure that all students regardless of race, gender, or disability are provided with opportunities to learn and understand the essential science content is the main basis of NSES defined as "science for all students" [2]. This dignified, meaningful and rigorous objective emphasized by NSES as "the commitment to Science for All implies inclusion not only of those who traditionally have received encouragement and opportunity to pursue science, but of women and girls, all racial and ethnic groups, the physically and educationally challenged, and those with limited English proficiency" [2]. So this fact has been emphasized by special educator as science education as one of the most useful and most valuable content area for many students with disabilities [3]. The affiliate of NSES, The Foundation for Science and Disability, founded in 1978, aspire to remove the barriers in order to enable active participation of students with disabilities to all activities of the scientific community, to have opportunities to choose careers in science, to provide the integration of them into the science, technological, engineering, and mathematical (STEM) [4].

Besides that the law that intend to provide all children with a fair, equal, and significant opportunity to obtain a high-quality education and to concern the way how to overcome the widening achievement gap between students from disadvantaged groups -defined as disabled, race, ethnic group, poverty or sex- and their peers known as No Child Left Behind Act (NCLB) emphasizes four essential principals; ensuring disadvantaged students achieve academic proficiency, offering more flexibility in using education funds, increasing parents awareness, and emphasizes educational programs based on scientific inquiry [5]. Reading/language arts, math and science are important subject under NCLB for developing yearly student academic assessments.

The development of many skills such as problem-solving, inquiry, thinking and learning are concerned with the development of through "hands on" activities with "minds on" grasp. One of the most pervasive and crucial goals of science education is to focus on the teaching and acquisition of basic and integrated science process skills [6]. Acquiring many of 21st-century skills such as critical and creative thinking, problem solving, decision-making, scientific literacy and information literacy can be fostered through scientific activities and scientific knowledge that is linked with reasoning and thinking skills [7].

Science content is less accessible to the students with blindness or low vision due to the overreliance on visual instruction and abstract nature of concepts. Therefore, students show significantly lower achievement in science compare to their sighted peers [8], [9]. The basic foundation of the teaching science, highly recommended being as manipulative and interactive with materials in the learning environment. Namely, exposing students to variety of experiences in science activities that can reasonably be explored is critical in stimulating the intellectual growth of students with visual disabilities [10]. By this way, student's awareness is expected to arise in science lessons [11], [12]. Students typically need variety of opportunities to explore and examine real materials or models by provide a wide range of hands-on learning experiences [13]. Besides that, some accommodations should be done in science classroom and laboratory in order to safely and fully access the science curriculum and to overcome the lacking in willingness to participate the science lessons [14]. On the other hand, carefully revising and rearranging the science education curricula, and considering how to make it accessible with characteristics of students with disabilities is the crucial point that special educators keep in mind [15], [16]. The students' unique needs mostly ignored when determining how to make materials accessible as well (i.e. measuring devices, reading charts and written materials, and laboratory equipment).

Although there are so many studies on students with visual impairment in the literature, only a few of them are about science education [17]. The content of these studies are usually related to the providing students with the ability to adapt to science courses, accommodations in the classroom and instructional material that students often need in science, technology, engineering and mathematics (STEM). In this study, we designed science activities and evaluated the efficacy of these activities on science process skills development.

## 2. RESEARCH METHOD

The study was conducted through design based research. As seen at Figure 1, DBR is used as a response to reduce widening achievement the gap between theory and practices in education issues, and to make educational research meaningful for the preferable educational systems. This fact is specified "design based research is a methodology designed by and for educators that seeks to increase the impact, transfer, and translation of education research into improved practice [18]. In addition, it stresses the need for theory building and the development of design principles that guide, inform, and improve both practice and research in educational contexts".

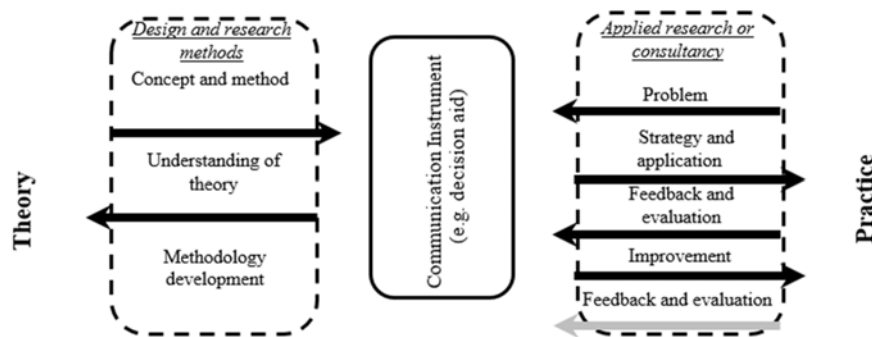


Figure 1. Theoretical structure of design-based research.

The study was carried out through these three steps. The case study was used at the first and third steps of the study. At the first the visually impaired students' unique needs related to science lessons were determined. Besides that, students' essential needs related physical environment, teaching, learning and assessment-evaluation process were analyzed to attain reasonable inference for accomplishment of design model. At this step, the embedded single-case study was used at first step of study to get enrichment data about students' needs mentioned above. Embedded case study contains more than one sub-unit of analysis, so that more complex (or embedded) design is to be developed to analyze all sub units and gather around a single purpose [19]. The subunits that are defined as students' needs (physical environment, teaching, learning and assessment-evaluation process) were analyzed for the significant contribution of the extensive analysis of the single case. Science Observation Form (SOF) was used as a data collection tool to determine the students' learning needs about science lesson. In the part designated as 'How was the lesson?' in the observation form is reversed to determination about how the course is carried out, the second part of the form is designated to analysis of the student' needs about lesson, and lastly the third part 'Observer Notes' is designated to the observer's evaluations.

At second step of the study, and activities and activity materials related to 'structure of matter' unit and also instructional materials (instructor's guide and student handouts) were designed in the direction of students' need that is determined at the first step. As a result, 9 activities were designed. An activity could include more than one learning outcomes. For example, for the learning outcomes defines as: 'recognize that the motion energies of each molecule may be different and will change with collisions' and 'interpret the temperature as a sign of the average kinetic energy of the molecules' and aim to teach the concept of temperature an activity of the were designed. Besides activity materials, the teaching methods techniques and the science process skills related to each activity were determined. For example, activity 1 were planned to develop the science process skill; observation, measurement-classification and analytical thinking.

Activity Based Instruction is as the teaching method used during the implementation of the activities at the classroom. ABI facilitate self-directed learning and problem-solving skills. Because it enables students to be willing with enthusiasm internalize and implement concepts relevant to their needs, make judgments on a subject based on activities and observations, and emphasizes the interactive interaction of the teacher with the them [20]-[22].

Instruction material designed for teacher contains the information about the purpose of activity, the common misconception student may have related about learning outcomes, the duration of each lesson, the question that teacher should ask during activities and the information about how the lesson should be processed. On the other hand, the handouts designed for student, basically contains the directives on what will be done during lesson and information about the activity materials. Activity materials that have been developed in accordance with the material development principles which are designated by special education and science education scholars are diversified to allow the use of hearing and tactile senses. By the way, the activity materials have been chosen from daily life to ensure the knowledge transfer between the activities to the daily life. Besides this, for the students with low vision Century Gothic font and font size 18 and for the blind students Braille documents were designed and used. Century Gothic and font size 18 was identified as the best readable font by visually impaired students [23]. At the implementation phase, instructional model was applied to students with visually impaired students. The implementation of the study has lasted nearly three weeks.

At the third step, Science Activity Observation Form (SAOF) was used as a data collection tool to analyze the effectiveness, applicability and usefulness of the instructional model. This stage was carried out

as an evaluated single-case design. Evaluative case studies involve in-depth description, explanation, judgement and analysis of causal links of a program, project, or other development activity.

### 2.1. Sample of study

The study has carried out at segregated school for visual impaired students. Sample of the study consist of four students. Purposive sampling enables us to studying a specific characteristic, feature or function and provide assist to be clear on informant qualifications about sampling. Sample of study presented in Table 1.

Table 1. Sample of the study

Student Code	Visual Acuity	Gender	Level of Inadequacy
S <sub>1</sub>	Blind	Male	Totally
S <sub>2</sub>	Blind	Male	Both eyes
S <sub>3</sub>	Low vision	Male	Both eyes
S <sub>4</sub>	Blind	Female	Both eyes

## 3. RESULTS AND ANALYSIS

The results obtained from the analysis of the observations are presented at this section. At need analysis stage, the students' needs for learning science lessons were determined by unstructured observations. At the implementation phase, semi-structured observations were made to determine the effectiveness, applicability and usefulness of the instructional design model. The results are presented as two subtitles as a needs analysis stage results and implementation stage results. The data obtained from the observations were subjected to descriptive analysis.

### 3.1. Needs results

In this section, the descriptive analysis of data that is gathered from SOF observation from will be given here. In order to ensure validity and reliability, the notes kept on the first observation form were compared with recorded videos after every lesson. Additionally a copy of the observation form was given two experts to watch the videos and record their observations. It was requested from experts to watch the activity videos and examine whether the activities were efficient on acquiring of planned skills. A common consensus is reached after examining the different analyzes. Table 2 shows observational data on needs analysis before designing of the first activity of the instructional design.

Table 2. Observation of the lesson

Concepts: Atom and molecule	
Duration: 45 minutes	
How was the Lesson?	The teacher is sitting at the same table after greeting the students. Then he starts a new topic after repeating the previous lesson. At this time, one of the two students who are sitting in front of the teacher listens to the teacher while he is trying to read the information about the topic. At the same time one of the blind students is struggling with Braille typewriters, another one is waiting by putting his head on the table and lastly the other one is sitting on doing nothing. The teacher teaches the topic through transition of knowledge by talking, considering that every student listens. In the meantime, the teacher describes the parts of the subject that contain the visual items without using any tools or materials to the students. Blind students listen to the lesson quietly while students with low vision are trying to follow the teacher's instructions from the textbook. The whole lesson is processed in this way.
Needs Identified	<ol style="list-style-type: none"> <li>Lack of instructional materials adapted to the visually impaired students</li> <li>The activities that aim to teach skills are needed</li> <li>Students' curiosity need to be supported by trying to answer as many questions as possible</li> <li>Concrete examples need to be given to the students</li> <li>The attention of students who are not interested in the lesson could be taken by the activities designed to provide fun and engaging learning</li> <li>Work sheets may be prepared to the students during and after class to summarize the topic of the lessons</li> </ol>
Observer Notes	The writing board is behind the students with low vision. Students needed to turn back to see the teacher's notes on the board. Besides that, the board is always covered with chalk dust. This can be a problem for students with low vision to be able to see what is written on the board. The material cabinets are also located in the entrance of the classroom. This can be regarded as acceptable for security reasons, but it may be more appropriate for students to be closer to them than to access to materials easily. The teacher mistakenly used the concepts of heat and temperature during the course (e.g. "temperature is transferred energy mmm. Aha, no sorry heat is transferred energy; temperature isn't energy). It is observed that the teacher deals with only a few students. Other students are not interested in the course.

It was observed that the teacher did not use essential teaching strategies effectively. Instruction was teacher-centered so the students were extremely unattended against what teacher teaches. Unfortunately

many students have misconceptions about the first and fifth learning outcomes that are concentrated on teaching the concepts of heat and temperature. A simple and concise activity may be designed by considering the students' unique needs. By this activity, which merely emphasizes tactile perception, students are expected to understand that heat is an energy type transmitted from cold to hot by the help of an ice sheet and hot water.

In Turkey, there are great difficulties in educating disabled people about science education. Since science teachers have no formal education on how to teach science to disabled students in their undergraduate education, unexperienced teachers are working in all special education schools. Therefore, science teachers are having problem in adapting instructional activities to the needs of students and having trouble motivating them. Through simple and effective activities, their (students and teacher) motivations can be increased. This can only be achieved with fun and effective activities. To carry out these activities effectively it was deemed to prepare a teacher's guidebook containing effective teaching strategies and activities.

### 3.2. Implementation

In this section, the findings obtained from the descriptive analysis of data that is gathered from SAOF observation from will be shown. In addition, a video recording and SAOF have given a specialist researcher to make a comparison between results. The very few differences arisen have been resolved after the concluding consensus on the findings of the specialist researcher. Table 3 describes analysis of activities according to science process skills.

Table 3. Analysis of activities according to science process skills

Activities		Obs	Mc	Dr	Hyp	U and m	Tv	Exp	Ct	Dm	C and t
1	Take	Yes	✓	✓					✓		
	place	No									
	Planned Situation		+	+						+	
2	Take	Yes	✓	✓					✓		
	place	No									
	Planned Situation		+	+						+	
3	Take	Yes	✓	✓	✓			✓			
	place	No									
	Planned Situation		+	+	+					+	
4	Take	Yes	✓				✓				✓
	place	No									
	Planned Situation		+				+				
5	Take	Yes	✓		✓						✓
	place	No		x							
	Planned Situation		+	+	+						+
7	Take	Yes	✓	✓	✓		✓				✓
	place	No									
	Planned Situation		+	+	+		+				+
8	Take	Yes	✓	✓					✓		
	place	No									
	Planned Situation		+	+						+	
9	Take	Yes	✓					✓			
	place	No									
	Planned Situation		+						+		

Activity took place: ✓, Activity did not take place : x

\*Obs: Observation, Mc: Measurement classification, Dr: Data recording, Hyp: Hypothesize, U and m: Using data and modeling, Tv: Testing variables, Exp: Experimentation, Ct: Critical thinking, Dm: Decision-making, C and t: Communication and team work

In the first activity, one of the students was asked to observe by holding two bottles filled with cold water and the other with hot water. With these observations based on tactile experience, students were able to observe temperature changes between the two materials. Simultaneously, the transfer of energy from the hand of the student to the ice and from hot water to student's hand occurs. The reason of being one of hand warm with time and the other hand cold simultaneously was questioned by putting analytical thinking

forward. According to observation in order to teach the concept of heat transfer in the first activity, integrating a phenomenon that occurs frequently in daily life has improved the positive attitude of students. Students want to be taught other lessons in this way, too. Table 3 shows the analysis of activities in terms of the science process skills.

In the design phase, the planned skill for each activity is shown as (+). The taking place of skills for each activity at the time of implementation is shown as yes (□) or no (x). According to these results, most of the planned skills that were designed were taken place. The only skills that do not take place are the ability to measurement classification related the 5th and using data and modeling related 9th activities.

#### 4. CONCLUSION

The mission of science education is to enable all students to use science process skill include observing qualities, measuring quantities, classifying, inferring, predicting, experimenting, and communicating to be able to define the real-world phenomena and problems around them. Meanwhile, the one crucial point that needs to be emphasized is that science process is not just convenient in science, but in any situation that requires critical thinking. So, laboratory works or in other words practical works in science education are quite important in terms of learning and skill development in science education. Therefore, practical work in science teaching that is acknowledged that promotes the engagement and interest and curiosity of students as well as developing a range of skills, science knowledge, and conceptual understanding. But it is a common accepted that science education particularly depends on intensive use of vision sense in order to receive the knowledge of the outside world or to be capable in recording information obtained by observation. Scientific knowledge is based on observational knowledge. It is accepted that observational evidence is crucial for the scientific discovery and the application of scientific theories to practical problems. Contrary to broad misunderstanding, observations are made with our own eyes, observation in science can be made by seeing, hearing, feeling, and smelling, too. However some of the blind individuals for example use non-vision senses such as hearing and touch for learning and functional tasks. Of course nobody thinks they should be deprived of the vast world of science because of having vision loss. The truth is that they typically need variety of opportunities to explore and examine real materials or models by touch or putting across through visual observation. Evidence shows that there is a serious educational gap both in bringing hands-on investigative activities into the classroom and in performing of science-enquiry principles especially at segregate schools. The findings of this study pointed out that there were great shortcomings in the whole process of teaching science instructions and in carrying out scientific practical works. As predicted there was poor reception of the science process skills.

In this study we have designed and developed activity and activity materials to meet students' needs related learning in science and to teach science process skills. Besides that these activities were aimed to develop scientific way of thinking by providing "multiple opportunities to work with these skills in different content areas and contexts". In addition to scientific process skills, the development of necessary social skills like as share, collaborate effectively, share, defend and extend ideas in groups was observed in this study. For example after implementation of the activities, we have witnessed one of the student these words: "This time I discussed scientific things with my friend whom I discussed for absurd things before. This was an interesting experience". As a result, the activities we have prepared for the development of the students' scientific process skills have been successfully implemented. Most of the skills planned for each activity have taken place. Unrealized skills can be explained by the fact that the students have had little activity before. It was observed that in the interviews made with the students after implementation of study, the students wanted the science lessons to be conducted in this way. But one the important points to consider is that designing instructional materials and activities for science requires a close collaboration of teachers, parents, students, and experts working on activity materials. Materials that are more appropriate to the students' unique needs can be developed by working in collaboration. The activities designed and developed according to the students' unique needs can be developed in social skills as well as the scientific process skills of the students. As visually impaired students easily get distracted by unnecessary details, to minimize distractions and allow them to focus on the main idea of the subject, activities and materials should be prepared as simple and as possible. This fact is especially essential in terms of time required for students to be able to socialize.

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